(19) Japan Patent Office (JP)

(12) Published Patent Application (A)

(11) Japanese Patent Application Laid-Open Number: No. 2001-43981 (P2001-43981A)

(43) Publication Date: February 16, Heisei 13 (2001.2.16)

(51) Int. Cl.^{7}	Identification Symbol	FI	Theme Code (Reference)
H05B 33/26		H05B 33/26	Z
G09F 9/00	342	G09F 9/00	342Z
9/30	336	9/30	336
	348		348A
	365		365Z

Request for Examination: Not Made

Number of Claims: 9 OL (9 pages in total)

Continued to the Last Page

(21) Japanese Patent Application Number: No. 2000-144704 (P2000-144704)

(22) Application Date: May 17, Heisei 12 (2000.5.17)

(31) Priority Number of Japanese Patent Application: No. H11-143331

(32) Priority Date: May 24, Heisei 11 (1999.5.24)

(33) Priority Country: Japan (JP)

(71) Applicant: 000003159

Toray Industries, Inc.

2-1, Nihonbashi-Muromachi 2-chome, Chuo-ku, Tokyo

(72) Inventor: Fujimori SHIGEO

c/o Shiga Plant of Toray Industries, Inc.,

1-1, Sonoyama 1-chome, Otsu, Shiga

(72) Inventor: Himeshima YOSHIO

c/o Shiga Plant of Toray Industries, Inc.,

1-1, Sonoyama 1-chome, Otsu, Shiga

(72) Inventor: Ikeda TAKESHI

c/o Shiga Plant of Toray Industries, Inc.,

1-1, Sonoyama 1-chome, Otsu, Shiga

(54) [Title of the Invention] Display Device and Manufacturing Method Thereof

(57) [Abstract]

[Objective] To form an effective guide electrode and to shorten the process thereof.

[Solution] A display device in which a borderline beyond which a base electrode is bare of a guide electrode and a borderline beyond which the base electrode is bare of an insulating layer are the same is advantageous in reducing resistance of a first electrode. A method in which after a stacked film of the base electrode and the guide electrode is patterned, and the insulating layer is patterned thereon, the guide electrode is removed by using the insulating layer pattern is advantageous also as a process.

[Scope of Claims]

[Claim 1]

A display device comprising:

a first electrode formed on a substrate; and

a second electrode provided facing the first electrode,

wherein the first electrode is a stack of at least a base electrode and a guide electrode,

wherein an insulating layer is formed on the guide electrode, and

wherein a borderline beyond which the base electrode is bare of the guide

electrode and a borderline beyond which the base electrode is bare of the insulating layer are substantially the same.

[Claim 2]

The display device according to claim 1, wherein the display device includes an organic electroluminescent element including the first electrode formed on the substrate, a thin film layer which is formed on the first electrode and includes at least a light-emitting layer formed of an organic compound, and the second electrode formed on the thin film layer.

[Claim 3]

The display device according to claim 1, wherein an opening shape in which the base electrode is bare of the guide electrode and an opening shape in which the base electrode is bare of the insulating layer are substantially the same.

[Claim 4]

The display device according to claim 1, wherein the base electrode is transparent.

[Claim 5]

The display device according to claim 1, wherein a cross section of the insulating layer in the vicinity of the borderline is a forward tapered shape.

[Claim 6]

A method for manufacturing a display device which includes a first electrode formed on a substrate and a second electrode provided facing the first electrode, and in which the first electrode is formed by stacking at least a base electrode and a guide electrode, comprising the steps of:

patterning a stacked film of the base electrode and the guide electrode at once;

forming a pattern of an insulating layer on the stacked film which is patterned; and

making a part of the base electrode bare by removing a bare portion of the guide electrode.

[Claim 7]

The method for manufacturing a display device according to claim 6, wherein patterning of the stacked film of the base electrode and the guide electrode is performed by a photolithography method.

[Claim 8]

The method for manufacturing a display device according to claim 6, wherein a pattern formation of the insulating layer is performed by a photolithography method.

[Claim 9]

The method for manufacturing a display device according to claim 6, wherein the bare portion of the guide electrode is etched and removed by using the insulating layer which is patterned as a mask.

[Detailed Description of the Invention]

[0001]

[Technical Field to which the Invention Pertains]

The present invention relates to a display device which includes a first electrode formed on a substrate and a second electrode provided facing it.

[0002]

[Conventional Art]

As an image display device (a display) which replaces big, heavy cathode-ray tubes, so-called flat panel displays, which are light and thin, are attractive.

[0003]

As a flat panel display, a liquid crystal display (LCD) has been spread, and there is an electrochromic display (ECD) as a similar non light-emitting type display. As a light-emitting type display which is attractive these days, there are a plasma display panel (PDP), an electroluminescent display (ELD), and the like. Among electroluminescent displays, especially an organic electroluminescent display is actively researched and developed because high brightness is obtained and full-colored display can be achieved.

[0004]

These flat panel displays are display devices which convert image information electric signal into image light, and many of them adopt a time-division driving method as their driving method. The time-division driving method is a method in which a screen is divided in accordance with a plurality of element electrodes, and a driving voltage is time-divided and added into these element electrodes. A dot-matrix-type electrode structure to realize this is generally an X-Y matrix structure, in which parallel and stripe electrodes are crossed at a right angle between a pair of electrode substrates facing each other. Sometimes the electrodes which are arranged facing each other in this way are indicated as an X electrode and a Y electrode, or they can be indicated as a first electrode and a second electrode.

[0005]

In flat panel displays, a transparent substrate and a transparent electrode are often used for one of the substrates in order to extract display light from one side of the substrate; however, the transparent electrode generally does not have high conductivity in many cases. In addition, in some cases, the electrode conductivity becomes

inadequate when the display gets bigger.

[0006]

[Problems to be Solved by the Invention]

In order to compensate the inadequate conductivity of the electrode, steps such as forming a base electrode on a substrate, forming a guide electrode thereon, further forming an insulating layer, and the like are performed. However, after forming each of the material films, it is needed to repeat operations such as applying resist, patterning, etching, and the like; therefore, the processes are complex.

[0007]

The present invention is to form an effective guide electrode and to shorten the process thereof.

[0008]

[Means to Solve the Problem]

The display device of the present invention is characterized by including a first electrode formed on a substrate, and a second electrode provided facing the above first electrode, where the above first electrode is a stack of at least the base electrode and the guide electrode, where the insulating layer is formed on the above guide electrode, and where a borderline beyond which the above base electrode is bare of the above guide electrode and a borderline beyond which the above base electrode is bare of the above insulating layer are substantially the same.

[0009]

In addition, the manufacturing method of the display device of the present invention is a manufacturing method of the aforementioned display device, and is characterized by including a step of patterning a stacked film of the base electrode and

the guide electrode at once, a step of forming a pattern of the insulating layer on the stacked film which is patterned, and a step of making a part of the base electrode bare by removing the bare portion of the guide electrode.

[0010]

[Embodiment Mode of the Present Invention]

The present invention relates to a display device including a first electrode formed on a substrate and a second electrode provided facing the above first electrode. Specifically, for example, an LCD, an ECD, an ELD, a display device in which an organic electroluminescent element is used, and the like are given.

[0011]

The present invention can be preferably applied especially to a display device which is formed using an organic electroluminescent element which includes the first electrode formed on the substrate, a thin film layer including at least a light-emitting layer formed of an organic compound which is formed on the first electrode, and the second electrode formed on the above thin film layer.

[0012]

In the present invention, the first electrode is a stack of at least a base electrode and a guide electrode, and an insulating layer is formed on the above guide electrode. The guide electrode and the insulating layer are provided only on part of the base electrode, and an opening where the base electrode is bare is formed. In the case where display light is extracted from the side of a transparent substrate, the base electrode is needed to be transparent, and the display light is extracted outside passing through the transparent base electrode and the transparent substrate through the above opening.

[0013]

The present invention is characterized in that a borderline beyond which the base electrode is bare of the guide electrode and a borderline beyond which the base electrode is bare of the insulating layer are substantially the same. More specifically, the opening shape in which the base electrode is bare of the guide electrode and the opening shape in which the base electrode is bare of the insulating layer are substantially the same. Here, substantially the same means not only the case where each of the borderlines or the opening shapes is completely the same as each other, but also the case where they are substantially the same. For example, when a guide electrode layer is etched by giving the insulating layer a function as resist as described hereinafter, even in the case where the borderlines of the guide electrode are not strictly identical with the insulating layer's ones because of under-etching of the guide electrode layer, they can be regarded as substantially the same.

[0014]

That is to say, in the present invention, the guide electrode is substantially formed on the whole part of the base electrode except for the portion where the base electrode relating to pixel display is bare, that is to say, the opening. And all of the guide electrodes exist in the state of being covered with the insulating layer. Therefore, the resistance of the first electrode can be reduced the most effectively without deteriorating the display quality of the display device. It is to be noted that, also as for an electrode lead-out portion, for example, if the edge portion of the base electrode is provided with the guide electrode and the insulating layer, and then is connected, around the center portion where the base electrode is bare, to an external circuit, the effect of reducing the resistance can be achieved.

[0015]

With reference to the drawings, the relation of the present invention between the guide electrode and the insulating layer which are formed on the base electrode is described. FIG. 1 is a plane view of a patterned base electrode 11. There is an opening 15 which is to be a pixel portion for display where the base electrode is bare, and the portion other than this bare portion is covered with an insulating layer 14. A guide electrode exists in the portion which is on the base electrode and is covered with the insulating layer. In this case, the guide electrodes exist at the both sides on the base electrode and between the openings; therefore, they exist longitudinally along the base electrode, thereby making a big contribution to the reduction of the resistance of the first electrode.

[0016]

FIG. 2 is a plane view illustrating one more example, in the present invention, which describes that the borderline beyond which the base electrode is bare of the guide electrode and the borderline beyond which the base electrode is bare of the insulating layer are the same. In this case, the insulating layer 14 is formed into a pattern traversing the base electrode 11, and guide electrodes 12 exist under the insulating layer which is above the base electrode. That is to say, the guide electrodes are provided intermittently having predetermined gaps on the base electrode. As a whole, the guide electrodes can contribute to the reduction of the first electrode resistance.

[0017]

FIG. 3 illustrates an X-X' cross-sectional view of a portion which is covered with the insulating layer and does not cross the opening in FIG. 1, and an X-X' cross-sectional view of a portion covered with the insulating layer in FIG. 2. In this

portion, the base electrode 11 and the guide electrode 12 have a stacked structure, and further are covered with the insulating layer 14. It is to be noted that, in the case where the second electrode is patterned by a partition method, it is preferable to form a partition on this insulating layer.

[0018]

On the other hand, a Y-Y' cross-sectional view crossed on the opening 15 in FIG. 1 is illustrated in FIG. 4. In this portion, the guide electrodes are formed at the both sides on the base electrode, and the insulating layer exists so as to cover the guide electrodes. That is to say, it is illustrated that a borderline 16 beyond which the base electrode is bare of the guide electrode and the borderline 16 beyond which the base electrode is bare of the insulating layer are the same. It is illustrated that the guide electrodes are formed on all of the base electrodes which are covered with the insulating layer.

[0019]

FIG. 5 and FIG. 6 are plane views illustrating another example, in the present invention, which describes that the borderline beyond which the base electrode is bare of the guide electrode and the borderline beyond which the base electrode is bare of the insulating layer are substantially the same. That is to say, a case is described where light-emitting regions of red (R), green (G), and blue (B) for full-colored display form a so-called delta arrangement, not a stripe pattern. For example, a base electrode which forms a pixel of one color is formed of a wide part which is to be a pixel and a narrow part which is connected to it, and this is formed for three colors. By the narrow part of the base electrode, the pixel portions are connected to each other, and the guide electrode and the insulating layer are formed on the base electrode so as to cross on the

pixel, which is preferable to reduce the resistance of the first electrode. In this state, further reduction of the resistance also can be achieved, by forming the guide electrode and the insulating layer also on the side portions of the pixel portion as illustrated in FIG. 1.

[0020]

In the present invention, as a base electrode material, a transparent conductive material is preferable, and tin oxide, zinc oxide, vanadium oxide, indium oxide, indium tin oxide (ITO), or the like can be used. For display use in which the patterning is performed, it is preferable to use ITO, which is superior in processability, as the base electrode. In order to improve the conductivity, a small amount of metal such as silver and gold may be contained in ITO.

[0021]

In the present invention, as a guide electrode material, aluminum, zinc, indium, tin, silver, gold, copper, chromium, titanium, nickel, or the like is used. For the guide electrode, two kinds or more of these metals can be stacked and used. A stacked film of chromium/aluminum or chromium/copper can be given as a preferable example from the viewpoint of reduction of the resistance, prevention of light-reflection, adhesion strength of the metal films, etching simplicity, and the like. In the present invention, the guide electrode is formed on the whole part of the base electrode except for the openings; therefore, in the case of using a metal such as chromium, which turns black, the guide electrode operates also as a black matrix, and contributes to the improvement of contrast in the display device.

[0022]

For the insulating layer, various kinds of inorganic and organic materials are

used. As an inorganic material; an oxide material such as silicon oxide, manganese oxide, vanadium oxide, titanium oxide, or chromium oxide; a semiconductor material such as silicon, or gallium arsenide; a glass material; a ceramic material; or the like is preferably used. As an organic material, a polymer material such as a polyvinyl-based, polyimide-based, polystyrene-based, acrylic-based, novolac-based, or silicon-based material is preferably used.

[0023]

Although the cross sectional shape of the insulating layer in the vicinity of the borderline beyond which the base electrode is bare of the insulating layer is not specifically limited, a forward tapered shape is preferable. When it is described with an organic electroluminescent device as an example, in the case where the cross section of the insulating layer is a forward tapered shape, an organic thin film layer 17 and a second electrode 18 are formed smooth also in the vicinity of the borderline 16 as illustrated in FIG. 15. It is preferable that the taper angle θ is 80° or less, further 60° or less, and further 45° or less. On the other hand, in the case where the cross section of the insulating layer is vertical, the tendency for the film thickness of the organic thin film layer 17 to become thinner in the vicinity of the borderline 16 is stronger as illustrated in FIG. 16; therefore, there is a risk that light emission of this region becomes unstable. In an extreme case, disconnection of an organic thin film layer is caused in the vicinity of the borderline, and a region where an organic thin film does not exist is formed, which sometimes lead to a serious defect formation of short circuit between the base electrode (the first electrode) or the guide electrode and the second electrode. Furthermore, the tendency of the film thickness of the second electrode to be smaller is stronger on the side wall portion of the insulating layer; therefore, also there is a risk of

causing the resistance of the second electrode to be increased. Although such a problem is possible to be avoided by devising a film forming method of the organic thin film layer or the second electrode, it is not so preferable that the cross section of the insulating layer is an inverse tapered shape (in a state where the taper angle θ is over 90°).

[0024]

A manufacture of the above-described display device whose borderlines beyond which the base electrode is bare of each of the guide electrode and the insulating layer are the same, and furthermore, whose opening shapes are the same can be performed in the following steps.

[0025]

A metal material which is to be the guide electrode is deposited on an ITO film of a substrate on which the ITO film which serves as a transparent base electrode is formed (FIG. 7). The film forming method of the guide electrode is not limited, and not only a deposition method but also a sputtering method, a laminating method, a plating method, or the like can be used.

[0026]

A stacked film of the base electrode and the guide electrode is patterned by a photolithography method at once (FIG. 8). Next, after lift-off resist pattern is formed on the patterned stacked film (FIG. 9), the insulating layer is formed on the whole surface (FIG. 10). The lift-off resist is removed; thus, the opening of the insulating layer is formed and the guide electrode becomes bare (FIG. 11). The guide electrode of this bare portion is etched and removed with the formed insulating layer as resist; thus, the base electrode becomes bare (FIG. 12). The pattern forming method of the

insulating layer is not limited to such a method of using the lift-off resist, and a method of applying an insulating layer material and etching it by a photolithography method, or patterning by using a photosensitive insulating layer material and performing light-exposure and development process thereon can be performed.

[0027]

The guide electrode at the portion which is on the base electrode and which is bare of the insulating layer can be removed by being etched with the patterned insulating layer as resist, and this is performed by using the etching selectivity ratio depending on materials used for the base electrode and the guide electrode. As the base electrode, an ITO film is frequently adopted; therefore, it is preferable to use a metal material which has a bigger etching selectivity ratio with respect to ITO as the guide electrode. What to use as an etching solution is also related; therefore, it is necessary that a combination of the guide electrode material and the etching solution be considered. That is to say, if it is Al, an alkaline solution can be used, and if Cr, as is well known, a solution formed of cerium ammonium nitrate, nitric acid, and water is used. In addition, if it is Cu, a solution of Ferric chloride can also be used. The ITO film may be etched to some degree; therefore, the range of the etching condition of the guide electrode can be regarded as having somewhat a wide range.

[0028]

In a conventional method, it was necessary to repeat photolithography processes at least more than three times for patterning the base electrode, patterning the guide electrode, patterning the insulating layer, and the like. However, in the present invention, only two photolithography processes are performed for patterning a stacked film of the base electrode and the guide electrode, and patterning the insulating layer.

[0029]

The opening in which the base electrode is bare of the guide electrode and the insulating layer corresponds to a unit which forms one pixel of the display device. For example, in a display device using an organic electroluminescent element, a thin film layer including at least a light-emitting layer formed of an organic compound is formed in this opening; furthermore, on the thin film layer, the second electrode is formed crossing the first electrode, so that the display device can be obtained.

[0030]

Steps of a manufacturing method of the display device of the present invention illustrated in FIGS. 7 ~ 12 can be used as a method of forming alignment marks of a mask, as they are, in the case where the thin film layer including at least a light-emitting layer formed of an organic compound and the second electrode are patterned and formed in the pixel portions. That is to say, alignment marks on which a stacked film formed of the ITO film and a guide electrode material film is patterned are formed on a plurality of appropriate positions on the substrate. When the ITO film is patterned, there is an example that alignment marks for the subsequent steps are formed sometimes. However, the detection of the marks formed of an ITO film in visible light is not easy. Thus, in order to facilitate patterning operation of the subsequent step including a light-emitting layer formation, it is useful to form alignment marks formed of the ITO film and the guide electrode material film which have high detection in visible light. In the case of the present invention, these alignment marks can also be used in a state of being covered with the insulating layer.

[0031]

[Embodiment]

Hereinafter, the present invention will be described with reference to embodiments; however, the present invention is not limited to them.

[0032] Embodiment 1

An ITO substrate in which a transparent ITO film having the thickness of 130 nm was formed on a surface of a non-alkaline glass substrate having the thickness of 1.1 mm by a sputtering deposition method was cut into a size of 120×100 mm. An aluminum film of about 100 nm was formed by a vacuum evaporation method on the ITO transparent film of this substrate. Photoresist was applied on this stacked film of the ITO film/the aluminum film, and then the photoresist was patterned by performing light-exposure and development by a normal photolithography method. After an unnecessary portion of the stacked film of the ITO film/the aluminum film was etched and removed, the photoresist was removed; thus, the stacked film was patterned into a stripe shape having the length of 90 mm and the width of 80 μm so as to be a first electrode. Eight hundred and sixteen 100-μm-pitch stripe patterns were formed.

[0033]

When the stacked film of the ITO film/the aluminum film was patterned, cross-shaped marks serving as alignment marks were formed on at least two positions of the corner portions of the glass substrate. The width of the lines of the cross-shaped mark was 20 μm and the length was 0.5 mm.

[0034]

Next, photoresist having the thickness of 3 μm for lifting-off (Nippon Zeon Co., Ltd. ZPN1100) was applied on the whole surface. As a photomask used for patterning this resist, a mask in which openings having the width of 65 μm and the length of 235

μm were arranged at 100 μm pitch in the width direction and at 300 μm pitch in the length direction was used. On the stacked film where the stripe pattern was formed, patterning was performed by aligning the width of 65 μm which is on the photomask so as to be placed at the center thereof. The pattern shape of this lift-off resist is characterized by an inverse tapered type. Subsequently, a silicon oxide film having the thickness of 150 nm was formed on the whole surface of the glass substrate by an electron beam evaporation method so as to be an insulating layer. By performing ultrasonic cleaning on this substrate in acetone, the lift-off resist was resolved and the silicon oxide film thereon was removed, so that the aluminum film became bare. In this manner, the insulating layer was provided with the opening having the width of 65 μm and the length of 235 μm were formed, at 100 μm pitch in the width direction and at 300 pitch in the length direction, which correspond to the patterning arrangement of the photomask used for patterning the lift-off resist.

[0035]

With this insulating layer as resist, alkaline etching was performed, and a bare part of the aluminum film was removed, thereby making the ITO film bare. The ITO film served as a base electrode, and the aluminum film served as a guide electrode. The borderline beyond which the base electrode was bare of the guide electrode and the borderline beyond which the base electrode was bare of the insulating layer were the same, and the opening shapes were a rectangular shape of 65 μm×235 μm and the same.

[0036]

After the substrate, on which the base electrode, the guide electrode, and the insulating layer were formed, and on which alignment marks were formed at the same time, was cleaned, it was set in a vacuum evaporation apparatus. In the vacuum

evaporation apparatus, a shadow mask to form a light-emitting layer, a shadow mask to form a second electrode, and some kinds of evaporation sources of materials to form the thin film layer including the light-emitting layer, and to form the second electrode can be set.

[0037]

The thin film layer was formed by a vacuum evaporation method with a resistance wire heating method. The degree of vacuum at this time was 2×10^{-4} Pa or less, and during the deposition, the substrate was rotated for the evaporation source. First, copper phthalocyanine of 15 nm and bis(*N*-ethylcarbazole) of 60 nm were deposited on the whole surface of the substrate as a hole-transporting layer.

[0038]

Next, a light-emitting layer formation was performed. The shadow mask to be used was formed in the following manner. That is to say, by precipitating a Ni-Co alloy on an electroformed mold by electroforming, a structure in which a stripe opening 32 was included, a reinforcing wire 33 formed crossing it existed, and a mask portion and the reinforcing wire were formed in one plane as illustrated in FIG. 13 was obtained. The outer shape of this shadow mask was 120×84 mm, and the thickness of a mask portion 31 was 25 μm. Two hundred and seventy two 300-μm-pitch stripe openings 32 whose length was 64 mm and whose width was 100 μm were arranged. On each of the stripe openings, the 1.8-mm-pitch reinforcing wire 33 having the width of 20 μm which crossed the opening at a right angle was formed. Furthermore, marks for alignment with the alignment marks formed on the substrate were formed at least two positions. A shadow mask was fixed to a stainless-steel frame 34 having the width of 4 mm which had the same outer shape.

[0039]

The above shadow mask to form a light-emitting layer was placed on the front of the substrate, and they adhere to each other, and on the back of the substrate, a ferrite magnet (YBM-1B made by Hitachi Metals, Ltd.) was placed. At this time, alignment marks on the substrate and position bases of the shadow mask were arranged so as to be correspondent to each other; therefore, they were aligned so as to place the stripe first electrode at the center of the stripe opening of the shadow mask, and to correspond the reinforcing wire with the position where the insulating layer existed.

[0040]

For the substrate placed like this, a red (R) light-emitting layer was formed. A host material of the R light-emitting layer was 8-hydroxyquinoline aluminum complex (Alq3) (20 nm), and was doped with 1 wt.% of 4-(dicyanomethylene)-2-methyl-6-(*p*-dimethylaminostyryl)-4-pyran (DCM) as the guest material.

[0041]

Next, in a state where placement of the shadow mask was shifted only by one pitch of the first electrode, a green (G) light-emitting layer was formed, for which the same Alq3 (21nm) as the R light-emitting layer was used as the host material; and 1,3,5,7,8-pentamethyl-4,4-difloro-4-bora-3a,4a-diaza-s-indacene (PM546), as the guest material. Furthermore, a blue (B) light-emitting layer was formed by shifting the shadow mask by one pitch. As the B light-emitting layer, 4,4'-bis(2,2'-diphenylvinyl)diphenyl (DPVBi) was used. In this case, 20 nm of DPVBi was only deposited without using a guest material. After that, 35 nm of DPVBi and 10 nm of Alq_3 were deposited on the whole surface of the substrate; finally,

the thin film layer was exposed to lithium vapor, thereby forming an electron-transporting layer.

[0042]

For patterning the second electrode, a shadow mask having a structure in which a gap existed between one surface of the mask portion 31 and the reinforcing wire 33, as illustrated in FIG. 14, was used. The outer shape of this shadow mask was 120×84 mm, and the thickness of the mask portion was 100 μm. Two hundred 300-μm-pitch stripe openings having the length of 100 mm and the width of 250 μm were arranged. Over the mask portion, the mesh reinforcing wire which had the width of 40 μm and the thickness of 35 μm, and which was composed of regular hexagons having the 200-μm interval between the facing sides was formed. The height of the gap was 100 μm which is the same as the thickness of the mask portion. Marks to correspond to alignment marks were formed also on the mask portion of this shadow mask in the same manner as the case of the shadow mask for forming the light-emitting layer. This shadow mask was used with fixed to the stainless-steel frame 34.

[0043]

The degree of vacuum when depositing the second electrode was 3×10^{-4} Pa or less, and during the deposition, the substrate was rotated for two evaporation sources. In the same manner as patterning formation of the light-emitting layer, a mask for the second electrode was placed on the front of the substrate on which up to the thin film layer had been formed, and they adhere to each other at a determined position by using the alignment marks, and on the back of the substrate, a plate magnet was placed. In this state, aluminum was deposited to the thickness of 240 nm, and the second electrode

was patterned. The second electrode was patterned into a plurality of stripe shapes arranged with gaps to cross, at a right angle, the first electrode patterned into a plurality of stripe shapes arranged with gaps.

[0044]

Through the above steps, a color organic electroluminescent element of a simple-matrix-type stripe arrangement was able to be fabricated, in which R, G, and B light-emitting layers patterned on 816 stripe first electrodes were formed, and two hundred 300-μm-pitch stripe second electrodes having the width of 250 μm were arranged crossing the first electrodes at a right angle. Three light-emitting regions of R, G, and B form one pixel; therefore, this light-emitting element had 272×200 pixels at 300 μm pitch.

[0045]

According to an evaluation of the display device composed of this organic electroluminescent element, the luminance unevenness was decreased compared with the case without a guide electrode, and a display device which had higher luminous efficiency was able to be obtained.

[0046] Embodiment 2

In this embodiment, polyimide was used as a material of which the insulating layer was formed. In the same manner as in Embodiment 1, after a stacked film of the ITO film/the aluminum film was patterned into a pattern as a first electrode, polyimide-based photosensitive coating agent (UR-3100 made by Toray Industries, Inc.) was applied by a spin coating method on the whole surface of the substrate, and was pre-baked with a clean oven under a nitrogen atmosphere at 80°C for one hour. Next, a portion to be left as an insulating layer was light-cured by being exposed in ultraviolet

rays through the same photomask as the one used for patterning the lift-off resist in Embodiment 1, and was developed by using a developer (DV-505 made by Toray Industries, Inc.). After that, the insulating layer was formed by being baked in the clean oven at 180°C for 30 minutes, and further at 250°C for 30 minutes.

[0047]

The display device was fabricated, with this polyimide insulating layer as resist, in the same manner as in Embodiment 1, as for the processes including and after etching and removing the bare portion of the aluminum film. Also in this case, the luminance unevenness was decreased compared with the case without a guide electrode, and the display device composed of the organic electroluminescent element which had higher luminous efficiency was able to be obtained. In addition, a relatively-thick insulating layer performed a function as a spacer, and was able to prevent the shadow mask from harming the thin film layer; therefore, the number of non light-emitting pixels was decreased compared with Embodiment 1, so that the further preferable display device composed of the organic electroluminescent element was able to be obtained.

[0048] Embodiment 3

On an ITO transparent film of the same substrate as in Embodiment 1, about 50 nm of chromium and further about 70 nm of copper were formed by a sputtering deposition method. Photoresist was applied on this stacked film of the ITO film/the chromium film/the copper film, and the photoresist was patterned by performing light-exposure and development by a normal photolithography method. After an unnecessary portion of this stacked film was etched and removed by Ferric chloride based solution, the photoresist was removed, so that the stacked film was patterned into a stripe shape having the length of 90 mm and the width of 80 μm so as to be the first

electrode. Eight hundred and sixteen 100-μm-pitch stripe patterns were formed. In the same manner as in Embodiment 1, cross-shaped marks serving as alignment marks were formed at least two positions on the corner portion of the glass substrate.

[0049]

Next, an insulating layer composed of silicon oxide was patterned in the same manner as in Embodiment 1. With this insulating layer as resist, and the bare portion of the copper film was first etched and removed by Ferric chloride based solution, thereby making the chromium film bare. Furthermore, the bare portion of the chromium film was etched and removed by a mixture liquid of cerium ammonium nitrate, nitric acid, and water, thereby making the ITO film bare. The ITO served as a base electrode; and a stacked film of chromium/copper, a guide electrode. The borderline beyond which the base electrode was bare of the guide electrode and the borderline beyond which the base electrode was bare of the insulating layer were the same, and the opening shapes were a rectangular shape of 65 μm×235 μm and the same. At this time, the adhesion of the guide electrode and the base electrode, and the insulating layer was improved, so that the defect such as a crack of the insulating layer was further decreased compared with in Embodiment 1.

[0050]

The display device was fabricated in the same manner as in Embodiment 1 as for the process after that. Also in this case, the luminance unevenness was decreased compared with the case without a guide electrode, and the display device composed of the organic electroluminescent element which had higher luminous efficiency was able to be obtained. In addition, chromium performed a function as a black matrix, and the display contrast was improved compared with in Embodiment 1.

[0051] Embodiment 4

In this embodiment, as a material to form the insulating layer, a positive type photoresist was used. In the same manner as in Embodiment 2, after a stacked film of the ITO film/the aluminum film was patterned into a pattern as a first electrode, novolac-based positive type photoresist (OFPR-800 made by TOKYO OHKA KOGYO CO., LTD.) was applied on the whole surface of the substrate to the thickness of about 3 μm by a spin coating method, and was pre-baked with a hot plate at 80 °C for 90 minutes. Next, ultraviolet light-exposure was performed through a photomask, and development was performed by using a developer (NMD-3 made by TOKYO OHKA KOGYO CO., LTD.). After that, the insulating layer was formed by baking with a hot plate at 180 °C for eight minutes.

[0052]

The display device was fabricated in the same manner as in Embodiment 2 as for the other steps. Also in this case, the luminance unevenness was decreased compared with the case without a guide electrode, and the display device having higher luminous efficiency was able to be obtained. In addition, in the same manner as in Embodiment 2, the effect of preventing the thin film layer from being harmed by a shadow mask was able to be observed. The cross section of this insulating layer was a forward tapered shape of about 45°, and uniform light emission was observed over the whole of the light-emitting region.

[0053] Embodiment 5

In this embodiment, the display device was fabricated in the same manner as in Embodiment 4 except for using the lift-off resist used in Embodiment 1 as a material to form the insulating layer. The cross section of this insulating layer became an inverse

tapered shape of about 90° ~ 110°; therefore, some relatively-thin portions of the organic thin film layer such as a hole-transporting layer and a light-emitting layer were formed in the vicinity of the borderline, so that light emission in this portion became unstable somewhat. However, compared with the case without a guide electrode, the luminance unevenness was decreased, and a display device having higher luminous efficiency was able to be obtained. In addition, the effect of preventing the thin film layer from being harmed by a shadow mask was able to be observed.

[0054]

[Effect of the Present Invention]

A display device in which a borderline beyond which the base electrode is bare of the guide electrode and a borderline beyond which the base electrode is bare of the insulating layer are the same is advantageous in reducing the resistance of the first electrode, and a display device composed of an organic electroluminescent element with less luminance unevenness, excellent color purity, and higher luminous efficiency. Furthermore, the cross section of the insulating layer is made to be a forward tapered shape, so that unstable light emission in the vicinity of the borderline can be prevented. In addition, the display device can be made in a fewer steps by being fabricated according to a method in which after a stacked film of the base electrode and the guide electrode is patterned, and the insulating layer is patterned thereon, the guide electrode is removed by using the insulating-layer pattern, so that it is also advantageous as a process.

[Brief Description of the Drawings]

[FIG. 1] A plane view illustrating one example of an opening formed at the same borderlines made by a guide electrode and an insulating layer on a base electrode.

[FIG. 2] A plane view illustrating a guide electrode and an insulating layer on a base electrode which are the same.

[FIG. 3] An X-X' cross-sectional view of FIG. 1 or FIG. 2.

[FIG. 4] A Y-Y' cross-sectional view of FIG. 1.

[FIG. 5] A plane view illustrating another example of an opening formed at the same borderlines made by a guide electrode and an insulating layer on a base electrode.

[FIG. 6] An X-X' cross-sectional view of FIG. 5.

[FIG. 7] A cross-sectional view illustrating a stacked structure of a base electrode film/a guide electrode film on the whole surface of a substrate.

[FIG. 8] A cross-sectional view illustrating a stacked structure film which is patterned.

[FIG. 9] A cross-sectional view illustrating a state where lift-off resist is patterned on the stacked structure film pattern.

[FIG. 10] A cross-sectional view illustrating a state where an insulating layer is formed on the substrate after forming lift-off resist pattern.

[FIG. 11] A cross-sectional view illustrating a state where an insulating layer is patterned by lifting-off.

[FIG. 12] A cross-sectional view illustrating a state where a base electrode is bare by etching and removing a guide electrode with an insulating layer pattern as resist.

[FIG. 13] A plane view illustrating one example of a shadow mask for patterning a light-emitting layer.

[FIG. 14] A plane view illustrating one example of a shadow mask for patterning a second electrode.

[FIG. 15] A cross-sectional enlarged view illustrating a situation where the cross section of the insulating layer is a forward tapered shape.

[FIG. 16] A cross-sectional enlarged view illustrating a situation where the cross section of the insulating layer has a right angle.

[Description of the Reference Symbols]

10	substrate
11	base electrode
12	guide electrode
13	lift-off resist
14	insulating layer
15	opening
16	borderline
17	organic thin film layer
18	second electrode
31	mask portion
32	opening of shadow mask
33	reinforcing wire*
*34	frame

Continued from the Front Page

(51) Int. Cl.^{7}	Identification Symbol	FI	Theme Code (Reference)
H05B 33/10		H05B 33/10	
33/14		33/14	A
33/22		33/22	Z